

in view and the City of Livermore is adjacent to the west end of the road.

The view of SNL/CA from Vasco Road includes the northwest portion of the buffer zone and at one point, a view of the Micro and Nano Technologies Laboratory's (MAN-TL's) building shape, roof, and exhaust stacks. Along most of the road, the view east includes rural residential areas and the distant open spaces beyond. To the west and adjacent to the road is the City of Livermore, which encompasses the entire view. To the north is LLNL, which dominates the view, though at the south end of the road distant hills to the north can be seen beyond LLNL. The view to the south is of distant hills.

The view of SNL/CA from Tesla Road includes South Portal Road and the gated entrance, and the water towers on the hills at the south end of the site. These hills effectively block any other view of the site from this road. On either side of the gated entrance are pastureland and vineyards, which encompass the view from the road to the north. Because Tesla Road is somewhat higher in elevation, the distant open spaces to the north can still be seen. To the south and east are views of agricultural areas and distant hills. At the west end of the road, the area is still agricultural, but the view west includes the City of Livermore and distant open spaces.

Greenville Road is on terrain higher than SNL/CA, but there are hills between the road and the site. Thus, views of the site are available from the road only between these hills. The view of the site from the northern end of the road includes the buffer zone and the eastern edge of the built area of the site, and the buffer zone and water tanks at the southern end. Also included in the western view are LLNL, the City of Livermore, and distant open spaces to the west, south, and north. Views south and east from the road are of agricultural open space and distant hills. The view north includes LLNL and agricultural open space, with hills in the distance.

The City of Livermore and the County of Alameda have identified certain scenic routes where an effort is being made to maintain the scenic view corridors (SNL/CA 2002b). While the city and county have no jurisdiction to enforce any requirements on SNL/CA, it is useful to note that of the eight roads identified as scenic routes, Greenville, Tesla, and Vasco are the only ones from which SNL/CA is visible. As explained above, the views of SNL/CA from these three roads are very limited.

## 4.4 GEOLOGY AND SOILS

### 4.4.1 DEFINITION OF RESOURCE

The discussion of geology and soils includes general geology, geological resources, geological hazards (seismology), and soils. General geology refers to topography, structural geology, and stratigraphy. Geological resources include

aggregate deposits, fossil occurrences, and oil production. Geological hazards include seismology (which refers to the geology below the soil layer that is relevant to the occurrence, frequency, and magnitude of earthquakes) and slope stability. The discussion of soils briefly describes soils present at the site and contaminated soils.

### 4.4.2 REGION OF INFLUENCE

The main concern of seismic activity is the effect on onsite facilities, specifically, whether damage from earthquakes could result in a contaminant release. Therefore, the ROI would be the extent of environmental or human health effects from such a release. Soil contamination could potentially result at or near the point of release. Thus, the ROI is limited to SNL/CA. Potential migration of soil contaminants into groundwater or surface water is addressed in Sections 4.5.1.3 and 4.5.2.3.

### 4.4.3 AFFECTED ENVIRONMENT

#### 4.4.3.1 General Geology

##### Topography and Geomorphology

SNL/CA is located in the California Coast Ranges geologic province (DOE 1992a, SNL/CA 2002b) characterized by low rugged mountains and relatively narrow intervening valleys. Figure 1-1 shows the location of SNL/CA relative to the surrounding area. Specifically, SNL/CA is located in the southeastern portion of the Livermore Valley. The valley forms an irregularly shaped lowland area about 16 miles-long east-to-west and 7 miles-to 10 miles-wide north-to-south. The floor of the valley slopes to the west at about 20 ft per mile.

In general, the site consists of relatively flat foothills that have low relief and slope gently northwest and north. Slopes at SNL/CA vary from 1 to 3 degrees. The southern area of SNL/CA is situated on the north side of a ridge (the Altamont Hills) approximately 150 ft above the surrounding land. The SNL/CA property ranges in elevation from 849 ft above MSL at the south end of the SNL/CA ridge top to 615 ft MSL at the northwest corner of the site.

##### San Francisco Bay Area Structural Geology

A generalized map of the regional structural geology and physiography of the San Francisco Bay Area is presented in Figure 4-3. The Diablo Range, which includes the Altamont Hills, is part of the northwest-trending Coast Ranges, and parallels three major faults in the area (DOE 1992a, SNL/CA 2002b). These include the San Andreas Fault system, the Sur-Nacimiento fault, and the Coast Range thrust fault system (the Sur-Nacimiento fault and the Coast Range thrust are not exposed in the area shown in Figure 4-3). These faults can generally be considered to define three different lithologic blocks. The

westernmost block is the Salinian Block, which lies west of the San Andreas Fault shown in Figure 4-3. This block consists primarily of metamorphic and granitic rock. To the east of the Salinian Block is the Franciscan Assemblage, lying between the San Andreas and the Coast Range thrust fault zones. It is composed of marine sedimentary and volcanic rocks. The next block positioned above the Coast Range thrust fault zone consists of late Mesozoic through late Tertiary marine sedimentary rocks overlying complex ancient oceanic and continental crust rocks. This block lies primarily along the eastern margin of the Coast Range Province. Structural relationships along the Coast Range thrust are complex due to later reactivation of the thrust by high-angle normal and strike slip faults.

#### **SNL/CA Site Fault Zones**

The two regional northwest-southeast trending fault zones located closest to SNL/CA are the Greenville fault zone and the Tesla-Ortigalita fault zones, both shown in Figure 4-3. To the west, the San Ramon Valley fault is located approximately 10 mi. Figure 4-4 shows the South Branch Las Positas fault, which traverses the southern most section of SNL/CA. The North Branch Las Positas fault cuts through the center of the SNL/CA site.

A geologic map showing general geologic structures including faults mapped near SNL/CA is presented in Figure 4-4.

#### **Stratigraphy**

Stratigraphic units exposed in the Livermore Valley and adjacent areas may be discussed in terms of three general groupings: Jurassic and Cretaceous igneous and metamorphic rocks; a sequence of primarily marine sedimentary rocks; and primarily continental rocks and alluvial deposits (see Figures 4-3 and 4-4). A generalized schematic stratigraphic column for the Livermore Valley is presented in Figure 4-5.

#### **4.4.3.2 Geologic Resources**

The geologic resources found near SNL/CA include aggregate deposits, fossil occurrences, and petroleum. These resources are described below.

##### **Aggregate Deposits and Other Mineral Resources**

The potential stone and aggregate resources of the eastern Livermore Valley and western San Joaquin County were assessed in 1987 and 1988. Mineral Resource Zones (SNL/CA is a Mineral Resource Zone 1) have been established that identify sand, gravel, and stone source areas. Within the eastern Livermore Valley, several deposits have been identified as recoverable and marketable resources (DOE 1992a). According to a report developed by the California Department of Conservation, Division of Mines and Geo-

### **What Does Mineral Resource Zone 1 Mean?**

Mineral Resource Zone 1 is defined as an area where adequate information indicates that no significant mineral deposits are present or where it is judged that there is little likelihood of their presence.

logy, an estimated 3.8 billion tons of aggregate reserves are available within the southern San Francisco Bay region, and the total aggregate reserves available within the Livermore Valley area amount to 676 million (M) tons; however, much of the area is currently developed for other land uses (SNL/CA 2002b).

Several occurrences of other potentially economically valuable mineral deposits are within a 10-mi radius of SNL/CA. These include deposits of manganese, chromium, clay, gemstones, pyrite, dimension stone, sand and gravel, and natural gas.

#### **Fossil Occurrences**

Fossils in the eastern Livermore Valley and the hills to the east are principally found in unconsolidated and poorly consolidated Cenozoic deposits. The primary fossil-bearing units are the Miocene Neroly and Cierbo formations, and some younger units of Pleistocene age (DOE 1992a). In the mid 1990s, excavation for the National Ignition Facility located on LLNL unearthed mammoth and horse fossils. Those fossils that would be affected by construction were excavated and curated at the University of California Museum of Paleontology at Berkeley (DOE 1999a, SNL/CA 2002b).

Other vertebrate fossil deposits near SNL/CA are in the Quaternary deposits of the surrounding low hills of the east Livermore Valley, but the fossils are few in number and quite scattered. They have been tentatively identified as Rancho La Brea and Blancan in age (Pleistocene) and consist of bone fragments of the mammoth and giant sloth (SNL/CA 2002b). Invertebrate shells and leaf and stem fossils have also been found. These appear to be randomly dispersed, mainly within the Neroly Formation. No invertebrate or botanical fossil deposits of significance are believed to be present in the eastern Livermore Valley (DOE 1992a, SNL/CA 2002b).

#### **Petroleum and Natural Gas Production**

The Livermore oil field just east of SNL/CA was discovered in 1967 and to date is the only oil field in the Livermore-San Ramon Valley area. The Livermore oil field was originally operated by the Hershey Corporation and consisted of ten producing wells. These wells are located northeast of SNL/CA. Production is primarily from

Miocene Cierbo Formation sandstones at depths of 900 to 2,000 ft. In 1992, the Livermore oil field was operated by the American Exploration Corporation. Of the original ten wells, five were producing an average of seven barrels of oil per day; one well was plugged and abandoned; three wells have been shut in; and one well was used for salt-water injection. Reserves were thought to be approximately 132,000 barrels and production was declining (DOE 1992a). In 2002, the XL Operating Company operated the Livermore oil field. In February 2002, only three wells were producing. No oil or gas exploration is currently being conducted or proposed for the Livermore Valley or in the hills to the east (CADC 2002a).

While Alameda County has no active natural gas wells, the closes field is located southwest of the City of Livermore approximately 7 mi. Contra Costa and San Joaquin counties have 26 and 63 producing gas wells, respectively. The closest gas field is located east of SNL/CA approximately 15 mi near the City of Tracy (CADC 2002a).

#### 4.4.3.3 Geological Hazards

##### Seismology

SNL/CA is located near the boundary between the North American and Pacific tectonic plates, and the area is characterized by the San Andreas Fault system, which trends southeast northwest. Three principal components of the San Andreas Fault system, the San Andreas, Hayward, and Calaveras faults, have produced the majority of significant historical earthquakes in the Bay Area. These three faults also accommodate the majority of slip along the Pacific and North American plate boundary and they would likely continue to generate moderate to large earthquakes more frequently than other faults in the region. The potential for local, damaging earthquakes was highlighted by the January 1980 Livermore earthquake sequence on the Greenville fault, which produced two earthquakes of magnitudes 5.5 and 5.6 on the Richter Scale. The earthquake caused structural and nonstructural damage to the SNL/CA facilities.

In most cases, Calaveras fault earthquakes in the Livermore Valley region have occurred on strike-slip faults, generally indicating north-south-oriented compression. The fault segment nearest SNL/CA may be capable of generating a magnitude 6 to 6.5 earthquake (DOE 1992a).

##### Slope Stability

SNL/CA consists of two different types of terrain separated by the north branch of the Las Positas fault. The area north of the fault (north of Arroyo Seco) consists of a relatively smooth land surface that gently slopes downward to the northwest. Because of the very low relief, the potential for slope instability on the northern portion of SNL/CA is remote. The terrain south of the Las Positas fault, however, contains greater relief and steeper slopes

that increase the potential for slope instability. The potential for slope instability in the southern portion of SNL/CA is considered moderate.

#### 4.4.3.4 Soils

Typically, surface soils and arroyo sediments cover the site. The soils beneath the site are formed primarily upon sediments deposited by local streams (Figure 4-5). Most of the deposits in the eastern part of the valley are relatively young, and thus soils are only moderately developed. These soils (generally loam) have minimal horizon, or development of layers, and can be several meters thick locally. Three soils cover most of SNL/CA: Rincon clay loam, Positas gravelly loam, and Livermore gravelly loam (SNL/CA 2002b).

#### Environmental Restoration Program

The Environmental Restoration Program activities began in 1984. By 1991, 23 solid waste management units were identified at SNL/CA. Of these locations, nine were identified for further investigation. The largest site, the Navy Landfill, is 2 acres in size. Investigation of these sites is regulated under the *Resource Conservation and Recovery Act* (RCRA). As of February 2002, ER activities at SNL/CA have progressed through a series of remedial and closure actions to the point where most sites have attained closure and active environmental monitoring is continuing on three sites: Fuel Oil Spill, Navy Landfill, and the Trudell Auto Repair Shop site. SNL/CA is working with the State on full closure requests and monitoring requirements.

## 4.5 WATER RESOURCES AND HYDROLOGY

### 4.5.1 GROUNDWATER

#### 4.5.1.1 Definition of Resource

Groundwater in the SNL/CA area occurs within saturated unconsolidated geologic material. The Livermore Valley has been divided into 12 groundwater subbasins based on the location of faults, topography, and other hydrogeological barriers that affect groundwater occurrence, movement, and quality. Figure 4-6 shows four drainage basins and numerous watershed boundaries.

#### 4.5.1.2 Region of Influence

SNL/CA is situated primarily within the Spring and Mocho I subbasins. The water-bearing sediments in the Livermore Valley include late-Pleistocene to Holocene-age alluvial sediments, generally less than 200 ft thick, which overlie Plio-Pleistocene alluvial and lacustrine Livermore Formation sediments up to 4,000 ft thick. The Livermore Formation consists of beds of gravel, sand, silt, and clay of varying permeabilities. Sandy-gravelly layers alternate with fine-grained, relatively impermeable layers, and